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Role of the Radiologist in Atomic Attack[1]

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In view of great advances made in new weapons of war, the position of the radiologist is rapidly becoming more important. Because of his general medical training, supplemented by his knowledge of radioactive materials and of their inherent dangers, he will be of invaluable aid to both the military and civilian population.

For some time one of us (S.L.W.) has been advocating the necessity of a well organized radiological defense program for California. Shortly after the initial attack in Korea, Governor Earl Warren of this state took an active part in mobilizing civilian personnel into a well organized civil defense organization. In the beginning, radiological defense was placed under medical control, as a part of the medical plan. It was soon realized, however, that an effective radiological defense program would of necessity have to be large in personnel, that it would require specialized training plans and equipment, and would best function as a separate entity apart from medical activities.

In an actual or potential atomic conflict an understanding of both the immediate and long-range implications of atomic warfare in all its aspects is required. An organization capable of coping with such a disaster must be developed. Trained personnel and instruments essential to the detection and measurement of radioactivity and the rapid radiological assay of food, water, and air must be provided. Plans must be made for the rapid assembly and evaluation of information regarding personnel and exposures to radiation and decontamination during the acute phases of the disaster. Also the potential long-range hazards will be of great importance.

It can probably be assumed that radiation injury will account for approximately 15 to 20 per cent of casualties from an air explosion of an atomic bomb. The remaining 80 to 85 per cent will be made up of burns, fractures, lacerations, contusions, etc., either singly or in combination. Because of the terrific destructive effects of the atomic weapons and because so much publicity has been given to them, it is essential that accurate information be disseminated to the civilian population regarding them. If this is not done, a serious psychological problem will develop. Fear and ignorance are always conducive to disaster.

The Legislature in California appropriated money to cover the cost of equipping and maintaining personnel for radiological defense training and for the compilation of information. A Radiological Defense Plan was prepared as an annex to the over-all State Civil Defense Plan. The outline of this annex is as follows:

I. Purpose
II. Basic policies and planning principles
III. Assumptions
  1. Assumed enemy actions
  2. Assumed results
IV. The essential problems
  1. Understanding of both the immediate and long-range implications of atomic warfare in all of its aspects
  2. Developing an adequate organization
  3. During acute phases of the disaster evaluation of the amount of radiation exposure and decontamination problems
V. Missions
  1. Pre-emergency
    (a) Training
    (b) Public information
    (c) Radiological intelligence
    (d) Meteorology
    (e) Instrumentation
    (f) Health physics
    (g) Special laboratories
  2. Alert phase

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3. Post-attack, acute phases
4. Post-attack, chronic phases

VI. Staff organization and responsibilities

As previously stated, the radiologists, because of their special training in medicine and surgery as well as in radiology, are in a better position than others to understand the fundamentals of radiation contamination and radiation effects on the individual.

Because of anticipated confusion and disorganization which may immediately follow an enemy attack involving atomic weapons, mobile radiological laboratories have been developed. These mobile laboratories can move rapidly into involved areas and determine how much radioactivity is present and what precautions are necessary for civil defense personnel. They can conduct rapid examination of air, water, and other materials, and may function, also, as mobile support and headquarters for monitor squads.

The use of these mobile laboratories in the long-range chronic phase following the use of radioactive weapons will be equally important. The continued survey of soils, plants, and animals and the investigation of all radioactive materials affecting public welfare will be necessary. Such mobile units will also be invaluable in the training of field monitors.

The laboratories (Fig. 1) consist of a 7 × 12-ft. aluminum body 6 ft. 4 in. high, mounted on a 2-ton, dual rear, truck chassis. They contain radiological assay instruments and the necessary accessories for the rapid determination of radiation levels in air, water, soils, food, and other materials, as well as some equipment for related chemical work. They carry an engine-driven, 115-volt, 3,000 or 3,500-watt A.C. generator, a water storage tank, a butane gas tank, and communication equipment. The State of California has contracted for sixteen such units at an approximate cost of $15,000 each.

The personnel for operating a mobile laboratory under emergency conditions would include two radiological assay technicians, two helpers, one driver, and one communications man. The technicians should be men from organizations which can make frequent use of the equipment in the pursuit of their normal activities during the pre-emergency phase. Under a state of extreme emergency, control of the mobile laboratories passes automatically to the Radiological Services Division of the Civil Defense Organization.

In the event of a major disaster, all radiologists should contact their local civil defense organization at once and find out their assignment. They should help provide leadership in planning community disaster medical and health services. Current literature on civil defense, radiation defense, first aid, blood and blood derivatives, etc., should be studied. Groups of radiologists should request and plan for refresher courses of a half-day or day on atomic medicine, radiation dangers, prevention of radiation contamination, instrumentation, phenomenology of the atomic bomb, importance of meteorology, and other subjects. Each metropolitan group of radiologists should get together and decide on a plan for their area and integrate it into the statewide plan for civil defense. Full cooperation should be given to the training of teachers of physics, chemistry, science, and of others as monitors. It is probable that most radiologists will be working with their medical teams or in hospitals in their specialty. Those especially trained or interested in radiation therapy will be used to form evaluation teams, to be composed of one radiologist, one physicist, one soil scientist, one biologist, and one meteorologist. There will be an evaluation team at the state, region, city, and or county levels.

During the first few hours or acute phase following attack with atomic and other weapons, considerable confusion will be present. Since most of the radiological defense personnel will be volunteers, there will be a short delay until they arrive at their posts. During this early phase it will be necessary for the protective services—law enforcement, fire, utilities, and engineering services—to have individuals in their groups trained and equipped with

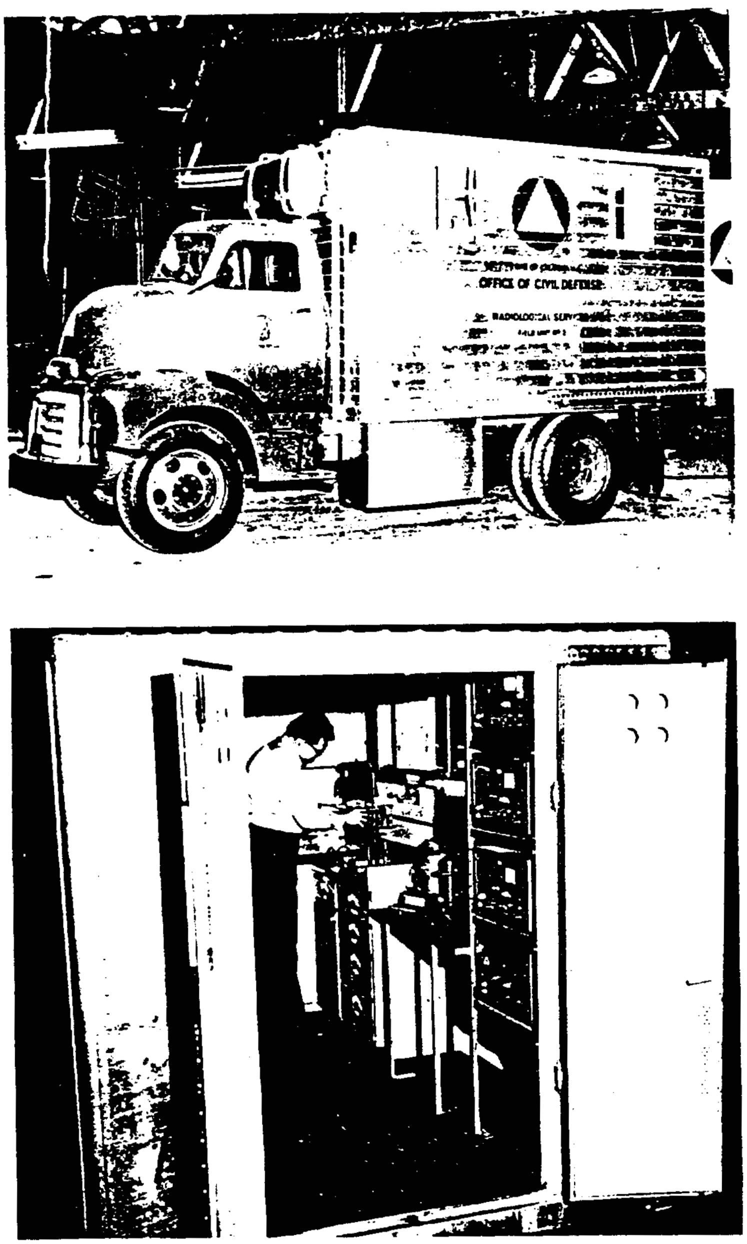

Fig. 1. Mobile radiological defense unit, exterior and interior views.

radiation detection instruments, the purpose being the making of one or two early reports of radiation levels immediately following the enemy attack and for their own protection. Members of these services, either in patrol cars or such installations as fire stations, police stations, utility depots and substations, are already deployed and equipped with their own communications. The necessity for making use of the protective services for some monitoring functions in the first several hours of a war-caused disaster arises out of difficulties and uncertainties about activating control centers and volunteer monitors within the first hours following an attack.

During the acute phase the radiologist and the radiological services will be busy finding and plotting the levels of radioactivity in areas important for emergency operations, examining food, water, and air for radioactive contamination, and evaluating hazards to residents and operating personnel (Figs. 2 and 3).

As the chronic long-range phases of the disaster develop, the radiological services and the radiologists will become more and more occupied with the long and difficult job of making systematic radiological surveys of the entire state. Such surveys will include the examination for internally stored radioactivity of many kinds in plants and animals, especially those destined for human consumption. It is not known how long it will take for the levels of radioactivity finding its way into the soil, air, and water, to exert any appreciable effect on the health of man. The atomic weapons which are most likely to increase the seriousness of the long-range problems are those which detonate near, at, or below the surface of the ground or water. If rain accompanies or falls soon after such air bursts, it will materially enhance the radioactive fallout.

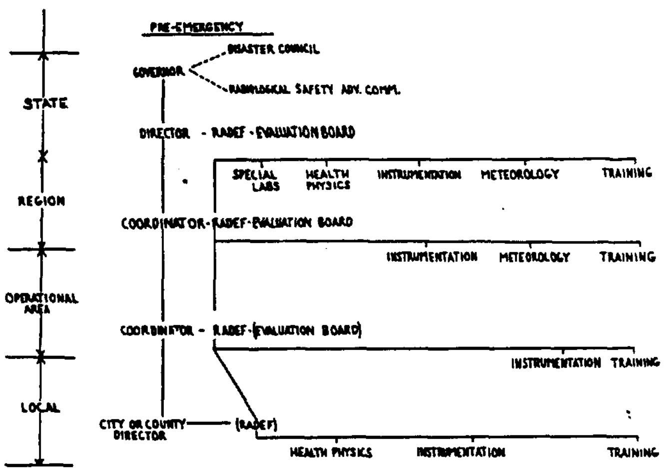

Fig. 2. Pre-emergency radiological civil defense plan for California.

There is little information available for estimating the degree of danger presented by any level of radioactive materials in the soil. Radioactivity in the soil may enter the human body in several ways:

(1) By inhalation of material which makes up a part of the air-borne dust.

(2) By ingestion of foods that have radioactive particles adhering to their surfaces or mixed with them.

(3) By the drinking of water from reser-

voirs that are supplied from the run-off over contaminated water sheds.

(4) By ingestion of food plants that have absorbed radioactivity from contaminated soil. Once radioactivity has entered into chemical combination within the plant, it may be transferred to animals or returned to the soil when the plant decays. Or these materials may cycle from soil to plant and to man directly, or from plant to animals and thence to man by way of such animal products as milk, butter, eggs, soup bones, etc. Eventually all these materials return to the soil to start the cycle all over again.

Food in moisture-proof bags or dust-proof containers and canned food will be safe but should not be used until after decontamination of the exterior of the container. It is not safe to decontaminate food exposed to the open air. Bale (1) is of the opinion that, for continued peace-time consumption of water or food by the general population, it is wise to restrict combined alpha and beta activity to less than 10^{-13} curies per c.c. where medium or long-lived isotopes are involved. Distillation of water in properly designed evaporators was done at Bikini.

All articles of clothing which have become grossly contaminated should be placed in suitable containers and, when time permits, should be buried at sea.

All physicians, nurses, and hospital personnel who are treating casualties from contaminated areas should be carefully monitored daily and, when necessary, decontaminated frequently. Similar monitoring will be necessary for firemen, policemen, rescue workers, etc.

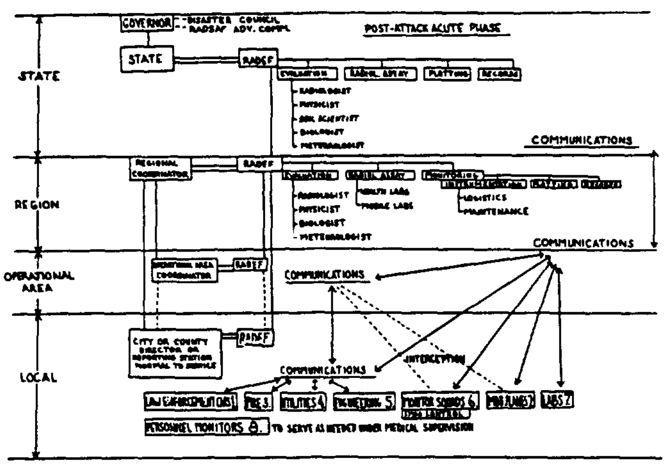

Fig. 3. Post-attack (acute phase) radiological civil defense plan for California. At the Communication centers there will be radiological evaluation boards.

In some instances casualties caused by inhalation or ingestion of radioactive materials may be more severe than those from external radiation.

The atomic bomb tests in Nevada in 1951 afforded the Division of Radiological Services of the State of California, Office of Civil Defense, a remarkable opportunity to study the hazards that would arise from airborne radioactivity following attack. The importance of meteorological information in prognosticating the patterns of dissemination of radiological materials was quickly appreciated (2).

It has been estimated that receiving

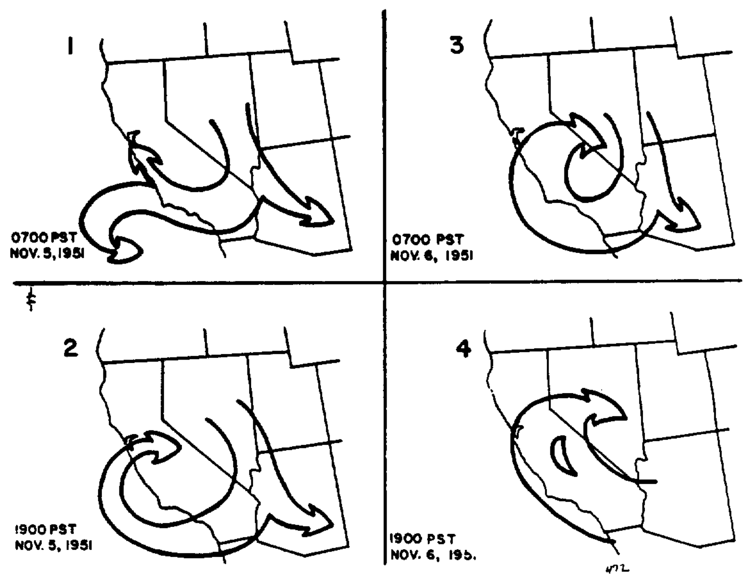

Fig. 4. Studies of the upper winds made at the same time on two successive days, illustrating the importance of meteorology in any radiological defense plan.

areas, etc., may be used for the first two days if radiation does not exceed 5 r per day. Also hospital emergency rooms and operating rooms should be evacuated after the first two days if the exposure rate is 5 r per day, or 1 r per day after the fifth day.

Suggested permissible exposures for monitors and others are as follows:

		Total
Acute period, 1st and 2nd days		
1st day	25 r	25 r
2nd day	10 r	10 r
Intermediate period, 3rd, 4th, and 5th days		
Per day	3.3 r	10 r
Later period, 6th through 56th day		
Per day	0.1 r	5 r
TOTAL		50.0 r

After the 56th day the present accepted tolerance level of 0.3 r/week applies.

For the decontamination of wounds, thorough irrigation may be done, but the main principle should be adequate débridement. Monitoring and partial decontamination of the less acute casualties can be done, but for those who are severely ill, with fractures, burns, etc., monitoring and decontamination may be detrimental. Persons with only minor injuries should have clothes, hands, hair, and feet monitored. If clothes are contaminated, they should be discarded into a proper container and the individuals given showers, with thorough cleansing of body folds, axillae, the skin under the nails, feet, and hair. Commercial detergents are very helpful. Severe trauma and shock should be handled as individual problems. Decontamination should continue where indicated to a minimum of 2 × peacetime permissible levels, *i.e.*, 1,000 millireps per week (surface measurements).

If necessary, titanium dioxide paste or a saturated solution of potassium permanganate may be applied to hands and feet, followed by a 5 per cent sodium bisulfite solution rinse.

TABLE I: SUMMARY OF CLINICAL SYMPTOMS OF RADIATION SICKNESS

Time after Exposure	Lethal Dose (600 r)	Median Lethal Dose (400 r)	Moderate Dose (300–100 r)
Immediately	Nausea and vomiting after 1 to 2 hours	Nausea and vomiting after 1 to 2 hours	
First week	No definite symptoms Diarrhea Vomiting Inflammation of mouth and throat	No definite symptoms	
Second week	Fever Rapid emaciation Death (Mortality probably 100 per cent	Beginning epilation Loss of appetite and general malaise	No definite symptoms
Third week		Fever Severe inflammation of mouth and throat	Epilation Loss of appetite and general malaise Sore throat Pallor Petechiae
Fourth week		Pallor Petechiae, diarrhea, and nosebleeds Rapid emaciation Death (Mortality probably 50 per cent)	Moderate emaciation (Recovery likely unless complicated by poor previous health and superimposed injuries or infections)

CLINICAL SYMPTOMS OF RADIATION SICKNESS

The symptomatology of radiation injury is not specific. It may be difficult to differentiate symptoms such as nausea and vomiting due to psychic disturbances from real radiation injury. Also individuals receiving the same amount of radiation exposure may react differently.

Damage to the lymphoid tissue is characteristic of radiation injury. Rapid lymphopenia is one of the few laboratory findings of value. Apparently one of the reasons for the hemorrhagic manifestations in the acute radiation syndrome is the decreased coagulability of the blood, believed to be caused by a circulating anticoagulant resembling heparin.

The clinical symptoms at intervals following exposure are summarized in Table I.

TREATMENT OF RADIATION INJURIES

All thermal burns should be treated as other types of burns, probably by some simplified method because of limited supplies.

All wounds which have been contaminated with radioactive material should be decontaminated by irrigation and by accepted surgical methods of débridement.

The treatment of radiation injury is symptomatic. There is no specific therapy. It is questionable whether any individual receiving 600 r body irradiation in a short space of time will survive, regardless of any method of treatment. The essential points in the treatment are as follows:

1. Absolute bed rest. Even for a month after the injury all physical activity must be limited.
2. Antibiotics such as Penicillin, Aureomycin, etc., for combating infections.
3. Intravenous feedings of glucose, proteins, and vitamins as indicated.
4. Blood transfusions to be given later; not in the beginning since it will be essential to conserve all blood bank supplies as much as possible. In the first few days blood transfusions will not be necessary for the radiation injured. Blood supplies will be in great demand for shock and surgical casualties. In the late radiation injury cases with petechiae and anemia the platelets are greatly diminished or absent, the blood fails to clot, and all wounds including needle puncture wounds ooze blood. There is no known method at the present time of checking the bleeding or producing clotting of the blood in these cases.

CONCLUSIONS

The fact that we are living in an age with the ever present possibility of widespread radioactivity of both an acute and chronic nature makes it imperative that we as radiologists learn as much as possible about atomic medicine. All radiologists should enter into and cooperate with any program for fact-finding, research, health, and decontamination, as affected by radioactive materials. Civil defense is here to stay, and the participation in it by all physicians, particularly radiologists, is a civic and patriotic duty.

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SUMARIO

El Papel del Radiólogo en los Ataques Atómicos

Por virtud de los grandes adelantos realizados en las nuevas armas de guerra, va tomando rápidamente mayor importancia el puesto del radiólogo. Debido a su adiestramiento médico general, complementado por el conocimiento de las substancias radioactivas y de los peligros inherentes en éstas, el radiólogo será un asesor insuperable.

Para cumplir su misión, tiene que estar al tanto de las obras de defensa pasiva en general y que formar parte de las comisiones asesoras de defensa radiológica, para la preparación de vigilantes y la educación del personal de defensa pasiva.

El diagnóstico y tratamiento de las lesiones por irradiación; la conservación de los repuestos de los bancos de sangre; la descontaminación de las heridas y de los lisiados en batalla o fuera de ella; los problemas del polvo esparcido por aviones; los problemas del agua potable y del alimento, todo esto corresponde a su dominio.

El radiólogo debe conocer a fondo y asumir las obligaciones que sobre él recaen durante el ataque atómico y antes y después del mismo.

Bosquéjase aquí el plan de defensa radiológica para el Estado de California y se describen los laboratorios movibles de radiología destinados a llevar a cabo los planes formulados.